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EDITORIAL COMMENT

Rock 'n Roll Ventricle of the Dyssynchronous Heart

Clinical Significance of Rocking Motion in Selection of Patient for Cardiac Resynchronization Therapy*

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Because a substantial subset of patients who receive cardiac resynchronization therapy (CRT) do not improve when selected based on QRS prolongation, numerous investigations have been performed to find other measures of intraventricular dyssynchrony, seeking better identification of patients who would benefit from CRT. The application of tissue velocity imaging to measure intraventricular mechanical dyssynchrony (time to peak systolic velocity of multiple left ventricular [LV] segments) was quickly adopted after several promising publications suggested that dyssynchrony indexes based on time to peak systolic velocity were effective in predicting response to CRT with a high sensitivity and specificity (1–3).

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However, clinicians and echocardiography laboratories were faced with 2 major challenges when we began to use tissue velocity imaging in candidates for CRT. The first challenge was the technical difficulty in measuring time to peak velocity and identifying the right peak velocity. It was frequent to encounter multiple systolic peaks from the same segment. Sometimes, the peak velocity during the isovolumic contraction period was higher than that from the ejection period. Which peak should be chosen among multiple velocities? Should it be the largest, the first, or only a peak during the ejection period? What is the physiological rationale for such selection? The second challenge was the clinical observation that some patients who were not predicted to respond to CRT based on tissue velocity imaging improved clinically and showed reverse remodeling after CRT, and vice versa. Subsequently, the multicenter prospective PROSPECT (Predictors of Response to Cardiac Resynchronization Therapy) trial and several other smaller studies showed that none of the tissue velocity-derived dyssynchrony indexes predicted LV reverse remodeling after CRT (4,5).

In this issue of *iJACC*, Phillips et al. (6) confirm again that tissue velocity-derived dyssynchrony does not predict reverse remodeling after CRT and explain how rocking motion of the heart, or longitudinal rotation, can affect the tissue-velocity waveform. When longitudinal tissue velocity is recorded from an apical view, complicated heart motion including transverse motion and torsion are dissected and only the component along the ultrasound beam is recorded as longitudinal velocity regardless of whether it is active contraction, passive pulled motion, or a combination. In the diseased heart particularly, the contribution of passive motion to the production of systolic tissue velocity is relatively large compared with the motion of a normally functioning heart. Heterogeneity of segmental contraction creates an imbalance in myocardial tension development, which increases the relative contribution of passive motion to longitudinal velocity. This imbalanced and dyssynchronous contraction will be pronounced if there is an electrical conduction delay such as a left bundle branch block. Such pronounced imbalance can be observed as a rocking motion in 2-dimensional echocardiographic images.

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Phillips et al. (6) quantified longitudinal rotation in 100 CRT candidates using 2-dimensional speckle tracking and divided patients according to longitudinal rotation quartiles. The first quartile patients who mostly responded to CRT with reverse remodeling had the highest clockwise rotation (apex swings laterally during systole with the LV in the apical 4-chamber view displayed on the right side of the screen), and their systolic dysfunction was predominantly due to nonischemic etiologies. In these patients, septal systolic velocity was higher than lateral systolic velocity. The opposite end of the spectrum was noted in the fourth quartile patients with modest counterclockwise rotation (apex swings toward the septum during systole, or almost no rocking motion) and a predominantly ischemic etiology. Their response to CRT was poor. In these patients, septal systolic velocity was smaller than lateral velocity. In addition, the septal-lateral velocity difference (not the absolute timing difference) was correlated significantly to the degree of longitudinal rotation. Their results imply that longitudinal rotation affects the longitudinal velocity by blunting the velocity of the wall in the direction of the longitudinal rotation and enhancing the velocity on the opposite side. In other words, septal and lateral systolic velocities are largely consequences of longitudinal rocking motion, rather than markers of myocardial contraction. The same group demonstrated that patients with clockwise rotation had higher strain in the lateral wall than septal strain, which is completely opposite to their velocity patterns (7). In the heart with prominent rocking motion, the longitudinal tissue velocity may no longer represent segmental myocardial contraction, and tissue-velocity waveform altered by the rocking motion may produce the multiple peaks responsible for measurement variability.

An important clinical question related to this novel observation of longitudinal rotation and related rocking motion is: Can we use this rocking motion as a surrogate for mechanical dyssynchrony to select candidates of CRT? It is not clear from the Phillips et al. article (6) whether velocities were measured only during the ejection period or the entire systolic period including the isovolumic contraction period. Because the extent of clockwise rotation was predictive of reverse remodeling, it may not be necessary to measure tissue velocities that appear to be a surrogate for longitudinal rocking motion. The observations in this article can be expanded to the qualitative assessment of rocking motion. A simple visual assessment of rotational motion was suggested to be good enough to predict the effect of CRT in a nonischemic population (8). A major weakness with this approach is that velocity difference and longitudinal rotation were able to predict the effect of CRT primarily in patients with nonischemic etiology for heart failure, but neither of them could predict response to CRT in ischemic cardiomyopathy patients.

How do we use the data presented by Phillips et al. (6)? Because it is clear now that time to peak systolic tissue Doppler velocities are not reliable methods to determine interventricular dyssynchrony, other more practical and reliable echocardiographic parameters are needed if echocardiography can be used for the purpose of selecting patients for CRT (9,10). Longitudinal rotation may be that parameter, but the parameter has to work in ischemic as well as in nonischemic patients and needs to be tested in a large prospective trial. It is possible that there is no simple echocardiographic parameter that can predict CRT response reliably. Predicting beneficial outcome from CRT is very complex. Although reverse remodeling or improvement in ventricular function has been most extensively used as a marker for positive response to CRT, lack of reverse remodeling does not mean negative response to CRT (11). We have also noted in our CRT patients that there is a poor correlation between changes in LV volumes and other end points (6-min walk or peak oxygen consumption) after CRT, which makes identification of ideal dyssynchrony parameters very challenging. Finally, we would like to suggest that the description of direction of rocking motion needs to be changed from "clockwise or counterclockwise" to "lateral or medial" rotation because there are different image display options in which the term "clockwise or counterclockwise" rotation can be confusing.

On a lighter note, Phillips et al. (6) who described the longitudinal rocking motion of LV are from Cleveland, which is the home of the famous Rock and Roll Hall of Fame and Museum. It may not have been a coincidence for the Cleveland team to recognize Rock 'n Roll LV motion of the heart in patients with systolic heart failure and intraventricular dyssynchrony in their efforts to identify clinically useful and widely utilizable echocardiographic parameters for potential CRT patients.

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